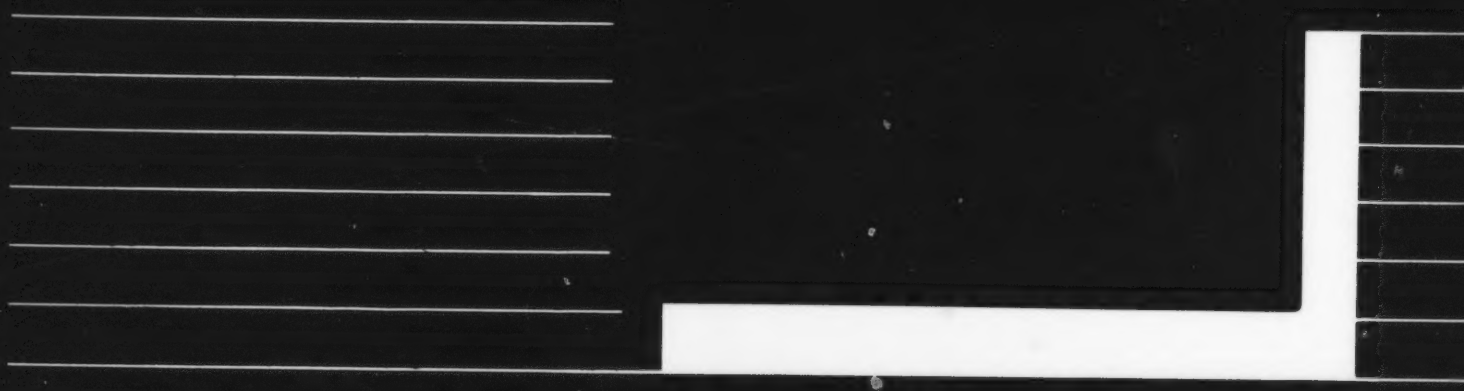
Bureau canadien de la sécurité aérienne

Canadian Aviation Safety Board



Rapport d'un fait aéronautique civil

Civil Aviation Occurrence Report

Canada

The Canadian Aviation Safety Board investigated this occurrence for the purpose of advancing aviation safety. It is not the object of the Board to determine or apportion any blame or liability.

AVIATION OCCURRENCE REPORT

AIR NOVA INC.
DE HAVILLAND DHC-8-102 C-GANF
ST. JOHN'S, NEWFOUNDLAND
14 FEBRUARY 1988

REPORT NUMBER 88A0039

SYNOPSIS

One minute and 19 seconds after the aircraft took off, the right engine flamed out and was secured. Two minutes and 50 seconds later, the left engine flamed out. After five seconds, the left engine relit and, in the following 17 seconds, returned to full power. The aircraft returned to St. John's and landed safely.

The Canadian Aviation Safety Board determined that ice, which had accumulated in the engine intakes while the aircraft was parked overnight, was not detected during the pre-flight inspection. The ice broke free during climb-out and disrupted the airflow to the engines.

Ce rapport est également disponible en français.

23 June 1989

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1.0 FACTUAL INFORMATION

1.1 History of the Flight

At 2036 Newfoundland standard time (NST)* on 13 February 1988, an Air Nova Inc., de Havilland DHC-8-102, registration C-GANF, arrived in St. John's, Newfoundland on a scheduled flight from Gander, Newfoundland. The same aircraft and crew were scheduled for a flight to Goose Bay, Newfoundland the following morning. They parked the aircraft on the ramp and secured it for outside overnight parking. During the night there was precipitation, including snow, freezing rain, and rain accompanied by strong winds. The temperature varied around the freezing mark.

At 1012 NST the next day, the aircraft departed runway 29 on a scheduled instrument flight rules (IFR)** flight to Goose Bay, Newfoundland. One minute and 19 seconds after take-off, while the aircraft was climbing through 1,800 feet above sea level (asl)*** in visual conditions, the right engine flamed out. The flight crew secured the engine and prepared for a right-hand visual approach to runway 29.

Two minutes and 50 seconds after the right engine flamed out, the left engine flamed out. When the pilot turned the aircraft toward the airport, he assessed that the aircraft was beyond gliding distance from the closest runway and selected a nearby frozen lake as an alternate landing site. Five seconds after it had flamed out, the left engine re-lit and, in the following 17 seconds, returned to near full power. The pilot then decided to complete a visual approach to runway 16, which was the closest suitable runway. After a successful single-engine landing, the aircraft was towed to the ramp.

The incident occurred near St. John's Airport, Newfoundland at lat 47°37'N, long 52°45'W at 1017 NST during the hours of daylight.

* All times are NST (Coordinated Universal Time (UTC) minus three and one-half hours) unless otherwise stated.

** See Glossary for all abbreviations and acronyms.

*** Units are consistent with official manuals, documents, reports, and instructions used by or issued to the crew.

1.2 Injuries to Persons

	Crew	Passengers	Others	Total
Fatal	-	-	-	-
Serious	-	-	-	-
Minor/None	3	20	-	23
Total	3	20	-	23

1.3 Damage to Aircraft

The aircraft was not damaged.

1.4 Other Damage

There was no other damage.

1.5 Personnel Information

	Pilot-In-Command	Co-Pilot
Age	26	26
Pilot Licence	Airline Transport	Airline Transport
Medical Expiry Date	01/08/88	01/04/88
Total Flying Time	8,400 hr	5,000 hr
Total on Type	1,500 hr	550 hr
Total Last 90 Days	210 hr	210 hr
Total on Type Last 90 Days	210 hr	210 hr
Hours on Duty Prior to Occurrence	1 hr	1 hr
Hours off Duty Prior to Work Period	15 hr	15 hr

1.6 Aircraft Information

Manufacturer	The de Havilland Aircraft Company of Canada Ltd.
Type	DHC-8-102 Dash 8
Year of Manufacture	1986
Serial Number	042
Certificate of Airworthiness	Valid
Total Airframe Time	4,282 hr
Engine Type (2)	Pratt & Whitney PW 120A
Propeller Type (2)	Hamilton Standard 14SF-7
Maximum Allowable Take-off Weight	34,500 lb
Recommended Fuel Types	Jet A1, Jet A, Jet B, JP-4, JP-5, JP-8

1.7 Meteorological Information

During the time the aircraft was parked overnight, it was exposed to a variety of weather conditions. The precipitation began as snow and blowing snow and, at 2110 NST, changed to a mixture of snow, blowing snow, freezing rain, and ice pellets. This mixture persisted until 2300 NST when the precipitation changed to rain for the remainder of the night. This was accompanied by strong winds gusting at times to 46 knots. While the aircraft was parked, the temperature rose to the freezing point at 2330 NST, reached an overnight maximum of 2.4 degrees Celsius at 0430 NST, and then fell to -0.5 degrees Celsius by take-off time.

At the time of departure, the weather was 1,600 feet scattered, measured 9,500 feet broken, and visibility 10 miles with no precipitation.

1.8 Aids to Navigation

Not applicable.

1.9 Communications

At the time of the occurrence, the crew was in contact with the St. John's Control Tower and Gander Area Control Centre. All communications were normal.

1.10 Aerodrome Information

St. John's Airport is at a reference elevation of 461 feet asl and has three 200-foot-wide paved runways. Runway 11/29 is 8,500 feet long; runway 16/34 is 7,000 feet long; and runway 02/20 is 5,025 feet long. All runways were serviceable at the time of the occurrence, but runway 02/20 was 100 per cent ice covered.

1.11 Flight Recorders

The aircraft was equipped with a Lockheed 209F digital flight data recorder (DFDR) and a Fairchild A100A cockpit voice recorder (CVR). Both recorders were analysed by the National Research Council, Flight Recorder Playback Centre under the supervision of the Canadian Aviation Safety Board.

The following sequence of events was obtained from the DFDR:

1012:41 - Take-off commenced;

1014:00 - Right engine flamed out, altitude 1,800 feet asl, speed 144 knots;

1016:50 - Left engine flamed out, altitude 2,000 feet asl, speed 160 knots;

1016:55 - Left engine re-ignited;

1017:08 - Left engine regained power;

1019:08 - Aircraft landed.

1.12 Wreckage and Impact Information

Not applicable.

1.13 Medical Information

There was no evidence found that incapacitation, physiological, or psychological factors affected the crew's performance.

1.14 Fire

Not applicable.

1.15 Survival Aspects

Not applicable.

1.16 Tests and Research

Not applicable.

1.17 Additional Information

1.17.1 Overnight Parking Procedures

Air Nova does not have a maintenance base in St. John's, and flight crews are responsible for installing the covers and protective devices necessary for outside overnight parking. To protect the engines from contamination, the flight crew installed intake plugs in the engine air intakes.

1.17.2 Pre-Flight Inspection

In the morning, when the crew arrived to prepare the aircraft for departure, there was no ice or snow visible anywhere on the aircraft. They discovered that the engine plugs had been dislodged by the wind and had been reinserted with additional rubber material around the edges to give them a tighter friction fit. In addition to the normal pre-flight inspection of the aircraft, the captain did an engine run-up to check for vibration which would indicate an ice buildup in the propeller spinners. There was no vibration.

The pre-flight inspection to be performed by the flight crew is outlined in Air Nova Standard Operating Procedures Dash 8 Walkaround Check-list. One item of this check-list is "Engine Intake - Clear." On the Dash 8, the inside bottoms of the engine intakes are not visible from ground level or from inside the aircraft.

1.17.3 Engine Intake Plugs

During the night when the strong winds had blown the intake plugs out, ground personnel from an associated company had reinstalled them after placing a rubber material around the diameter of each plug to make a tighter fit.

The plugs were initially inserted by the flight crew at about 2100 NST and were found dislodged and reinstalled at about 2400 NST. It could not be determined how long the plugs had been out.

The ground personnel did not inform the flight crew that the plugs had been dislodged and had been reinstalled; however, this was obvious to the crew because of the addition of the rubber material.

The inlet plugs being used at the time were the original plugs supplied with the aircraft by the manufacturer and were made from polyethylene foam. The plugs were designed for a friction fit, but they have a history of blowing out of the intakes in windy conditions. The operator had attached a line to each plug and secured the line to the aircraft so that if a plug blew out, it would not blow away.

A newer model of the plug is now being produced. The new plug uses a dense sponge material, which provides a tighter fit and is less susceptible to being blown out in windy conditions.

1.17.4 Ice Formation in Engine Intakes

The inside bottoms of the engine air intakes are shaped like shallow bathtubs, and drain holes are incorporated to prevent water from pooling in the bottom if rain should enter when the aircraft is parked.

After the occurrence, the engine intakes were examined. A sheet of ice approximately one and one-half inches thick partially covered the bottom of each intake. Sections of the ice in each intake had broken away. Additional ice buildup was found directly in front of the bypass door of each engine (see Appendix A).

The ice remaining in the right engine covered the rear half of the bottom of the intake scoop. The front half of the bottom of the intake was clear. A clean break line was noted where the ice, which had been in the front portion of the intake, had broken free. There was a lesser amount of ice remaining in the left engine intake; however, enough ice remained to provide evidence that an amount similar to that found in the right engine had at one time been present in the left engine.

1.17.5 Engine Ignition Procedures

The Dash 8 was certified under United States Federal Aviation Regulation (FAR) Part 25, FAR 36, and Special FAR 27. The engines were certified under FAR Part 33. FAR 33.69 (Ignition Systems) states in part that "each engine must be equipped with an ignition system for starting the engine on the ground and in flight."

The Dash 8 has a three-position ignition switch for each engine; OFF, NORMAL, and MANUAL. The normal position is used for starting, and engine ignition is automatically turned off on completion of the start sequence. The manual position provides continuous ignition to the engine.

FAR 25, Chapter 25.1309 Paragraph B, outlines reliability requirements for the aircraft equipment, systems, and installations. In general, this paragraph discusses the testing required to determine the probabilities of failure. During certification of the engine, strenuous testing was conducted to prove that the engine would not flame out, even when subjected to such adversities as water ingestion, bird strikes, and foreign-object ingestion.

At the time of certification, it was determined, through this testing process, that the chance of engine flame-out on this engine was so remote that continuous ignition was not required during take-offs and landings in normal conditions.

There is a requirement for manual ignition to be selected when the aircraft is operating below 1,500 feet above ground level (agl) in the vicinity of any storm cloud formation. This restriction was imposed because the engine electronic fuel control units and associated circuitry are considered vulnerable to transients induced by lightning strike. In addition, manual ignition should be selected when operating in the air or on the ground in conditions of turbulence, icing, or heavy precipitation. The Aircraft Flight Manual (AFM) defines when icing conditions exist including when the static air temperature (SAT) on the ground and for take-off is 10 degrees or below when operating on ramps, taxiways, or runways where surface snow, ice, standing water, or slush may be ingested by the engines or freeze on the engines, nacelles, or engine sensor probes. None of these conditions was judged to exist when this aircraft started its take-off, so manual ignition had not been selected.

1.17.6 Engine Failure Check-lists

For easy reference in the cockpit, the aircraft manufacturer had produced a quick reference check-list (QRC). Air Nova produced an identical QRC for its crews' use. A discrepancy existed between these QRCs and the relevant check-list in the AFM current at the time of the occurrence.

This AFM check-list for an engine power loss or shutdown contained the following procedure:

"Ignition switches - operating engine - manual; failed engine - off."

The QRC contained two different engine shutdown procedures:

1) "Engine failure or fire on take-off after V1" - normally to be used if an engine failure occurs below 1,000 agl; and,

2) "Engine shutdown in flight" - normally to be used above 1,000 feet agl. (This is the check-list used by the crew in this occurrence.)

The QRC "engine failure or fire on take-off after V1" check-list differed from the current AFM in that it simply stated, "ignition switch - off" for the failed engine and did not call for the ignition switch on the operating engine to be turned to manual.

2.0 ANALYSIS

2.1 Introduction

The investigation indicated that ice had formed in the engine intakes from precipitation which entered the intakes while the engine intake plugs were out. After take-off, some of this ice broke free, causing the engines to flame out from the momentary disruption to the airflow.

2.2 Weather Conditions

During the time the plugs were out of the intakes, the temperature was at or below the freezing point, and the aircraft was subjected to snow, blowing snow, freezing rain, ice pellets, and rain. For the drain holes to be blocked, some freezing or frozen precipitation had to accumulate in the bottom of the intakes. Since the freezing precipitation changed to rain at 2300 NST, it is likely that the plugs were dislodged before that time. Although the temperature rose to above freezing during the night and melted the ice or snow from the fuselage and wings of the aircraft, the temperature was not high enough to melt the accumulation in the intakes and clear the intake drains.

2.3 Pre-flight Inspection Procedures

Company procedures require that the engine intakes be inspected on the pre-flight inspection, the accepted practice being a visual inspection from ground level. However, the bottoms of the intakes are not visible from the ground, or even from the top of the airstairs or from inside the aircraft. It would have been necessary for the crew to utilize a ladder in order to gain an unobstructed view of the inside of the intakes.

Although both the company and the crew knew of the poor retention qualities of the intake plugs in windy conditions, neither was aware of any problems associated with contamination of the engine intakes as a result of this poor retention. They were, however, aware of the problem of ice buildup in the propeller spinners, and the crew carried out a run-up to ensure the spinners were clear of ice. The run-up showed there was no ice in the spinners, and, as there was no ice or snow clinging to any part of the aircraft, the crew had no reason to believe that any extraordinary pre-flight inspection procedures were necessary.

2.4 Engine Flame-out

The ice continued to adhere to the bottom of each intake until, as the airspeed increased during climb-out, the suction of the passing air caused some of the ice to break away. When the front half of the ice in the right engine broke free, the momentary disruption to the engine intake air caused the engine to flame out. There was no possibility of an automatic engine re-light because the ignition switch for that engine was in the normal position.

In securing the right engine by use of the "Engine Shutdown In-Flight" QRC, the crew selected manual ignition for the left engine. When the ice gave way in the left intake scoop, the left engine flamed out, however, it automatically re-lit because the ignitors were on.

During the certification process, the engine, mated to the DHC-8 engine intake cowl, passed rigorous testing designed to demonstrate resistance to flame-out and mechanical damage caused by foreign object ingestion. The engine intake cowl is designed so that foreign objects of a size unacceptable to the engine bypass the engine inlet. During the occurrence, the ice already in the intake broke free, and the resultant sudden disruption of the airflow entering the engine inlets was sufficient to cause flame-out. The lack of impact damage within the engines suggests that the ice mass broke up, and the majority of the pieces exited through the bypass doors opened by the crew before take-off.

2.5 Engine Failure Check-list Procedures

For easy reference in the cockpit, the aircraft manufacturer had produced a QRC. Air Nova produced an identical QRC for its crews' use. The specific manufacturer's QRC copied by Air Nova reflected the AFM current when Air Nova accepted their first Dash 8 aircraft. At that time, the AFM required ignition to be selected to manual during every take-off and subsequently switched to normal by the time the aircraft was at 1,000 feet agl. Therefore, a requirement (during an engine failure drill) for the selection of ignition to manual below 1,000 feet agl would have been redundant. When the AFM was subsequently changed, the operator did not change the QRC.

The AFM current at the time of this incident required that the ignition be selected to manual before take-off only in specific conditions; these conditions did not exist for the incident take-off. In the AFM current at the time of the incident, only one engine shutdown procedure for all airborne emergencies was specified.

Because the aircraft was above 1,000 feet agl when the right engine flamed out, the flight crew used the "Engine Shutdown In-flight" QRC, which called for manual ignition on the operating engine to be turned on. Had the flame-out occurred at an altitude below 1,000 feet agl, and the QRC aboard the aircraft for "Engine Fire or Fail V1" been used, the manual ignition on the left engine would not have been turned on, and the engine would not have re-lit.

3.0 CONCLUSIONS

3.1 Findings

1. The design of the original polyethylene foam engine intake plugs was such that they were susceptible to being blown out by the wind.

2. The engine plugs were blown out by the wind.

3. Ice which had accumulated in the bottom of the engine air intakes was not detected at the time that the plugs were reinserted.

4. There was no communication between the flight crew and ground personnel about the fact that the intake plugs had been removed for a period of time.

5. The bottom of each engine intake was not examined during the pre-flight inspection; therefore, the ice was not detected.

6. The ice broke free during climb-out, disrupting the airflow to the engines and causing them to flame out.

7. The "Engine Fire or Fail After V1" quick reference check-list did not conform to the current Aircraft Flight Manual.

3.2 Causes

Ice, which had accumulated in the engine intakes while the aircraft was parked overnight, was not detected during the pre-flight inspection. The ice broke free during climb-out and disrupted the airflow to the engines.

4.0 SAFETY ACTION

4.1 Action Taken

4.1.1 Dash 8 Engine Intake Plugs

On 23 February 1988, the aircraft manufacturer issued Advisory Notice No. 27 to all Dash 8 operators, Transport Canada, the Federal Aviation Authority, and the Civilian Aviation Authority outlining the events of this occurrence. This Advisory Notice recommended that a visual inspection of the engine intakes be undertaken prior to engine start-up if the aircraft has been parked without the engine intake plugs in place, or if there is any reason to believe that the plugs may have been temporarily dislodged, and the aircraft has been subjected to precipitation in temperatures below 10 degrees Celsius.

Recognizing the shortcomings with respect to the fit of the Styrofoam engine intake plug originally designed for the Dash 8, the manufacturer introduced a more durable one of polyethylene material with improved retention characteristics. Accordingly, the Canadian Aviation Safety Board forwarded an Aviation Safety Information Letter to Transport Canada in May 1988 suggesting that all Dash 8 operators be apprised of the availability of the new intake covers; the aircraft manufacturer has subsequently done so. Furthermore, the air carrier of this occurrence took the extra precaution of supplying its aircraft with its own redesigned engine intake covers that fit over the intake and are secured to the engine cowling.

4.2 Further Action Required

4.2.1 Operating Procedures - Manual Ignition

During the early stages of the analysis of this occurrence, it was reasoned that, had the ignition switches been "on", then a double engine flame-out would have been unlikely. Since the Aircraft Flight Manual for the Dash 8 did not call for engine ignition switches to be selected to MANUAL for normal take-offs and landings, the Canadian Aviation Safety Board issued an Aviation Safety Advisory to Transport Canada suggesting that consideration be given to the mandatory use of manual ignition for all take-offs and landings in Dash 8 aircraft. In response to this advisory, Transport Canada found it unneccessary from an airworthiness perspective to make changes to the DHC-8 approved Flight Manual based

on this incident. However, Transport Canada sent to the manufacturer the suggestion to consider revising their Operation Manual Procedures to reflect the use of manual ignition for all take-offs and landings.

The Board notes that Advisory Notice No. 27 issued by the manufacturer now recommends adherence to the procedures entitled "Operations in Icing Conditions" as outlined in the Aircraft Flight Manual; i.e., manual ignition should be selected when operating in the air or on the ground at 10 degrees Celsius or below and where snow, ice, standing water, or slush may be ingested by the engines. The Board also notes that some Canadian air carriers, including Air Nova, have instituted company Dash 8 operating procedures calling for ignition to be selected to MANUAL for all take-offs and landings, irrespective of the ambient conditions.

Notwithstanding the actions taken, the Board remains concerned that there may be operating conditions beyond those already covered in de Havilland's Advisory Notice No. 27 which may warrant the selection of the ignition switch to the MANUAL position for all take-offs and landings in the Dash 8. Furthermore, the Pratt & Whitney PW 120 series of engines is incorporated in several other types of aircraft for which such an operating practice may be warranted. The Board is not aware of any technical reasons which would contra-indicate such use of manual ignition. In view of the potential consequences of an engine flame-out on take-off or landing, the Board recommends that:

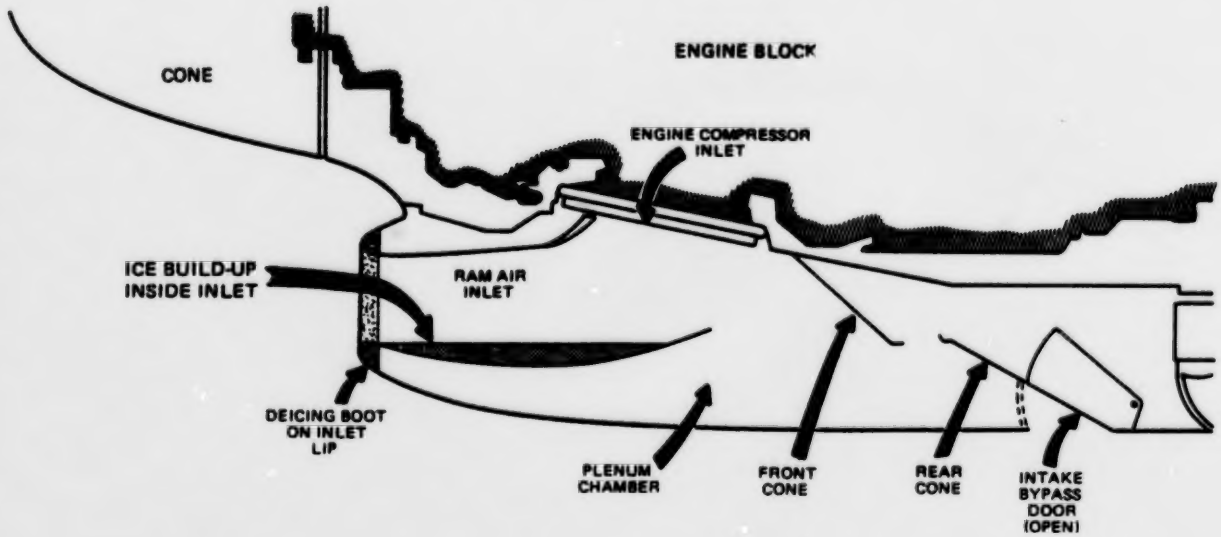
> The Department of Transport require the selection of the ignition switch to MANUAL for all take-offs and landings on Dash 8 aircraft.

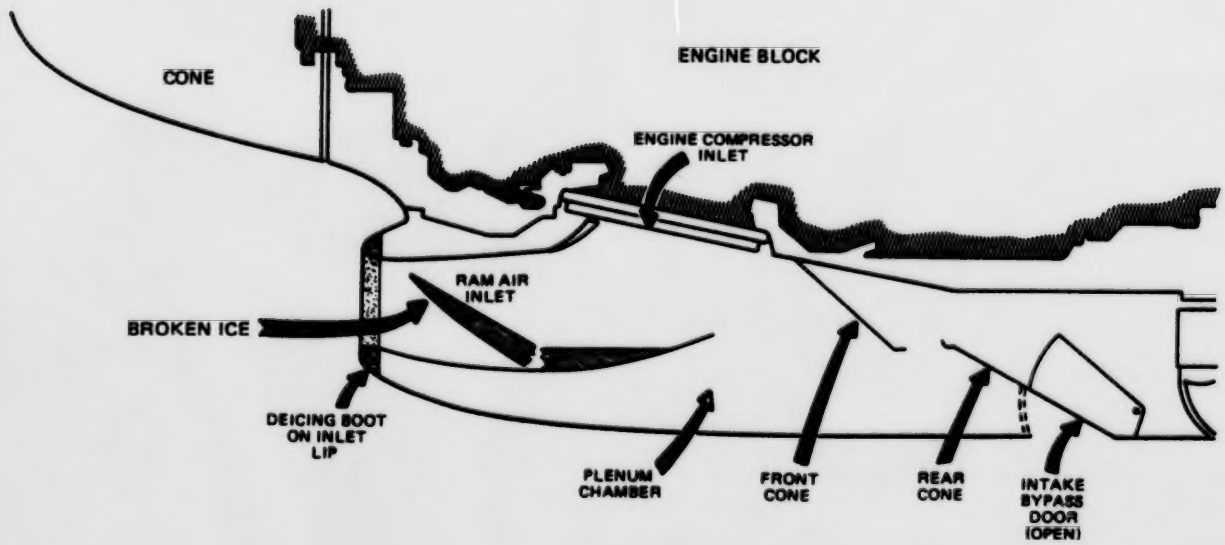
CASB 89-07

This report and the safety action therein has been adopted by the Chairman, K.J. Thorneycroft, and Board Members:

N. Bobbitt
L. Filotas
A. Portelance
B. Pultz
R. Stevenson
F. Thurston

DASH-8
INLET DIAGRAM





GLOSSARY

AFM	Aircraft Flight Manual
agl	above ground level
asl	above sea level
CVR	cockpit voice recorder
DFDR	digital flight data recorder
FAR	Federal Aviation Regulation
hr	hour
IFR	instrument flight rules
lat	latitude
lb	pound(s)
long	longitude
N	north
NST	Newfoundland standard time
QRC	Quick Reference Check-list
SAT	static air temperature
UTC	Coordinated Universal Time
V_1	critical engine failure recognition speed
W	west
°	degree
'	minute(s)